NOLTR 61-24

CHARACTERIZATION OF SQUIB MK 1 MOD 0:

5-Megacycle RF Sensitivity for Long Duration Pulses

24 APRIL 1961

NOL

UNITED STATES NAVAL ORDNANCE LABORATORY, WHITE OAK, MARYLAND

NOLTR 61-24

CHARACTERIZATION OF SQUIB MK 1 MOD 0:
5-Megacycle RF Sensitivity for Long Duration Pulses

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Chief, Explosion Dynamics Division

ABSTRACT: The response of the Squib Mk 1 Mod 0 to 5-Megacycle constant current (RMS) has been extended to long input times where the current amplitude for firing reaches a minimum asymptotic value. For a current amplitude of 374 milliamperes a pulse width of 155 milliseconds was found necessary to obtain 50-percent fires. When the current was allowed to flow for approximately 10 seconds (essentially steady state) a lower firing level of 308 milliamperes for 50-percent response was determined. These values are consistent with previous data obtained at 5 megacycles for shorter pulse times and also with DC constant current firing data.

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Explosions Research Department
U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

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The work reported on here has been carried out as part of the Naval Ordnance Laboratory's participation in the HERO (Hazards of Electromagnetic Radiation to Ordnance) program supported by Tasks 506-925/56015/07040, 506-924/56035/01073, and NOL-443. The objective of the HERO effort at NOL is generally to characterize the response of electro-explosive devices to electric and electro-magnetic energies. This report describes the results of tests to determine the response of the Squib Mk 1 Mod 0 to small amplitude, long time, constant-current (RMS) 5-megacycle pulses.

This work should be of interest not only to the HERO project but also the broad field of electro-explosive device design, development, manufacture, and use.

W. D. COLEMAN
Captain, USN
Commander

C. J. Aronson

C. J. ARONSON
by direction

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INTRODUCTION

As part of its task on the Hazards of Electromagnetic Radiation to Ordnance (HERO) program, the Naval Ordnance Laboratory is determining the response of the Mk 1 Mod 0 Squib to various electrical stimuli. One input stimulus under investigation has been 5-megacycle constant-current (RMS) pulses. The response of the squib to pulses at this frequency, compared to its response at DC, is of interest in assessing and predicting hazards from communication equipment.

Measurement of the response of the Mk 1 Squib to 5-megacycle stimuli has already been carried out and reported (1) by this Laboratory for current levels of approximately 1, 2, 3, and 4 amperes. Data for lower amplitude currents at 5 megacycles have not been obtained. It is a common observation that there exists for each particular EED a lower firing current level below which the EED will not fire. This is an important parameter in characterizing the EED with respect to the safety in handling it. This report describes the work carried out to obtain the response of the Mk 1 Squib at lower amplitudes in order to better define its minimum firing current level and to further establish the overall shape of the firing current-pulse width relationship. The conclusion previously drawn--that there is no significant difference between the response of the Mk 1 Squib to DC stimuli and to 5-megacycle constant-current (RMS) stimuli--is still valid for the low-amplitude long-duration pulses.

THE EXPERIMENTAL MEASUREMENTS

The Apparatus. The 5-megacycle constant-current firing data previously obtained and reported are summarized by Figure 1, and are shown to serve as proper background for the additional data to be presented in this report. It can be seen from Figure 1 that the previous data did not establish the lower firing level, i.e., small amplitude large time inputs for the 5-megacycle frequency. The apparatus previously used, except for the standard resistor, could not be used for the present work because the pulse time could not be extended beyond approximately 1 millisecond. Consequently, different instrumentation had to be developed for the experiments of the present work. However, the standard resistor, which was previously assembled and calibrated with much care, was also used in these present experiments.

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(1) NavWeps Report 7309, "Characterization of Squib Mk 1 Mod 0: 5-Megacycle RF Burst Sensitivity", 16 December 1960, L. Green and C. Goode.

It was desired to establish two additional data points for the 5-megacycle constant-current (RMS) -- pulse width relationship. One point was desired at the lowest firing level (minimum current possible for infinitely long input times); the other point was desired between the lowest point established in reference 1 (1 ampere) and this minimum firing level.

The apparatus assembled consisted basically of a 5-megacycle unit oscillator,* a power supply for the oscillator, and a coaxial safety switch to isolate the firing pulse from the squib in the firing chamber until it was desired to deliver the firing pulse. In establishing the lower firing level, the apparatus was operated at CW. For the "in-between" point the apparatus was modified to contain an RC pulse forming network to allow variation of the pulse width as desired. Figure 2 shows a block diagram of the apparatus used including the two oscilloscopes which monitored the pulse amplitude and/or pulse width. The basic monitoring was performed by observing the potential drop across the standard resistor in series with the squib to be fired. The firing was at constant current because the input impedance of the oscillator was high (50 ohms) compared to the squib impedance. Variations in squib impedance during the firing cycle (changes of about 30 to 40 percent of the average 1-ohm bridge resistance) were negligible in comparison to the 50 ohms which acted as a current limiting ballast in the circuit.

The basic monitoring was necessary to obtain accurately the amplitude of the current, and, for the "in-between" point, the pulse width. The current amplitude during each firing was set approximately by eye by adjusting the potential drop across the standard resistor. The final current amplitude, however, was taken by reading with a comparator the photograph of the CRO trace.

Monitoring of the potential drop across the squib was also performed in case it was desired to calculate the change in squib impedance and the energy delivered to the squib during the firing pulse.

<u>The Experimental Procedure</u>. The data for both points were obtained by the Bruceton stair-step procedure [(2)]. For the minimum current point the "on-time" of each pulse was held constant at 10 seconds and the current level was adjusted in accordance with the Bruceton plan using arithmetic current steps. Squibs which did not fire in the 10 seconds were taken to be at

---

*A General Radio Model 1211B or equivalent.

(2) AMP Report 101.1R SRG-P No. 40, Statistical Analysis for a New Procedure in Sensitivity Experiments, July 1944. See also W. J. Dixon and F. J. Massey, "Introduction to Statistical Analysis" (McGraw Hill Book Co., Inc., New York, 1957).

equilibrium temperature-wise and therefore considered to be "no-fires".* It was attempted to set the current steps 25 milliamperes apart. As explained previously, the levels were set as best possible by eye using the potential drop across the standard resistor. Later, from the photographic records the actual setting was read by use of a comparator. The comparator readings for each step (level) were then averaged to obtain the best estimate of the numeric value of the level to be used in the analysis of the results. This produced a non-uniform step size and, although the mean firing level computed is accurate, the standard deviation should not be used to compute any other percent firing point.

The data point between the lowest level of reference 1 and the minimum firing current was obtained using a variable pulse width Bruceton test plan. The current was set constant by eye at approximately 0.375 amperes. The monitor was again used to obtain the best average of the constant-current settings. This average turned out to be 0.374 amperes. The pulse width, as previously explained, was varied by the pulse forming network.

RESULTS AND CONCLUSIONS

The data obtained in the fixed pulse length—variable current test (minimum firing level) are shown in Figure 3. The average minimum firing current (50-percent fires) was determined to be 0.308 milliamperes. This value compares well with the DC minimum firing current of 0.3 milliamperes. (3) Because the Mk 1 Squib does not have a normal distribution of response to energizing stimuli (4) and because of the modification needed to analyze the experimental data indicated above, no attempt is made to prescribe a no-fire level for 5-megacycle energy sources.

The data obtained in the fixed current-variable pulse width test are shown in Figure 4. The mean average pulse width was determined to be 155 milliseconds for the 0.374-ampere fixed current level.

*This is not unreasonable since the Mk 1 Squib has a thermal time constant of approximately 4 milliseconds. A time of 10 seconds is thus equivalent to 2500 time constants.

(3) "Cartridge Actuated Device Igniter Handbook", Atlantic Research Corp., 18 June 1958, (prepared under contract NOrd 17497)

(4) NavWeps Report 7347, "Characterization of the Squib Mk 1 Mod 0: Determination of the Statistical Model", L. D. Hampton and J. N. Ayres, 30 January 1961.

The two points determined are plotted in Figure 5 and are consistent with the data of reference 1. They show that there is no significant difference in the response of the Mk 1 Squib to constant current supplied at DC or 5 megacycle (RMS).

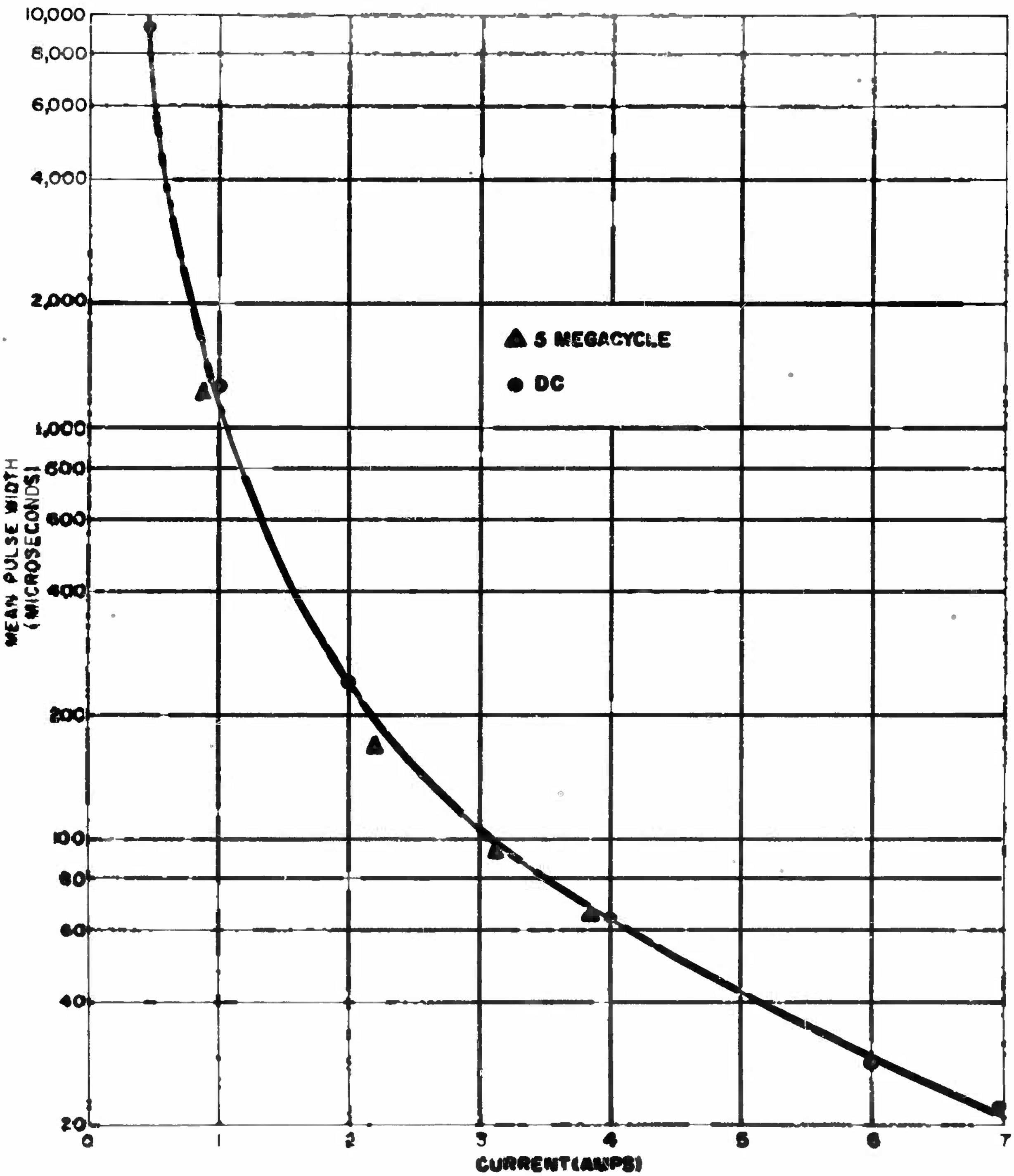


FIG. 1 COMPARISON OF DC AND 5-MEGACYCLE CONSTANT-CURRENT FIRING RESULTS

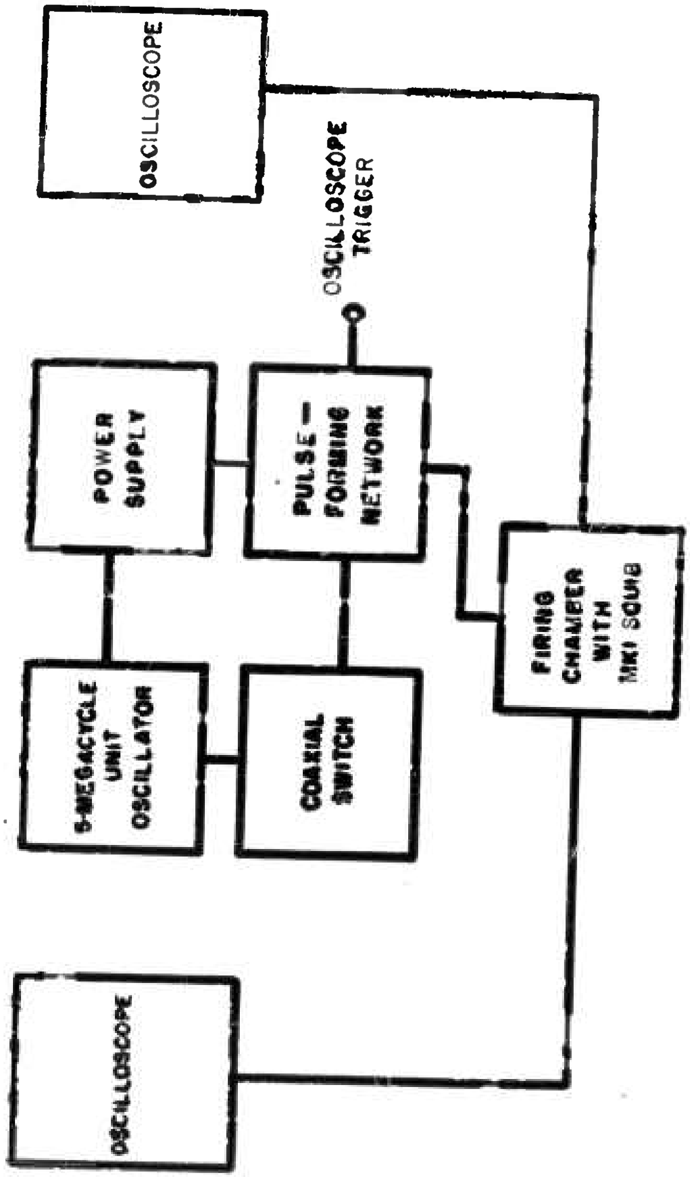


FIG. 2 SCHEMATIC OF FIRING APPARATUS

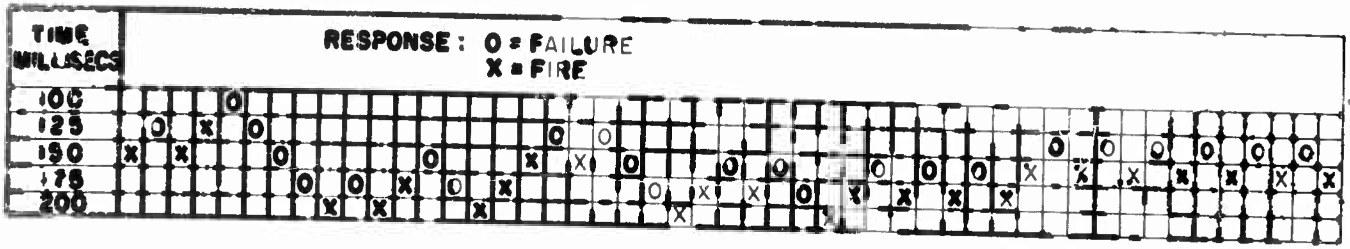
CURRENT (MILLIAMPS)	RESPONSE : O = FAILURE X = FIRE																																								
350													X																												
332				X				X				O		X		X												X		X		X		X				X		X		
308	X		O		X		O		X		O				O		X		X		X		X		X		O		O		O		O		X		O		O		O	
279		O				O				O								O		O		O		O		O										O						

INPUT TIME CONSTANT AT 10 SECONDS. CURRENT AMPLITUDE VARIABLE.

BY BRUCETON ANALYSIS

MEAN CURRENT (50 % FIRES) = 309 MILLIAMPS

FIG. 3 RESPONSE OF SQUIB MKI MOD 0 TO CONSTANT-CURRENT (RMS) 5-MEGACYCLE PULSE. TIME OF PULSE IS 10 SECONDS.



CONSTANT (5 MEGACYCLE/SEC) CURRENT OF 374 MILLIAMPS. TIME VARIABLE.

BY BRUCETON ANALYSIS

MEAN TIME (50% FIRES) = 158.2 MILLISECS.

FIG. 4 RESPONSE OF SQUIB MKI MOD 0 TO CONSTANT-CURRENT (RMS) 5-MEGACYCLES PULSE. CURRENT AMPLITUDE IS 374 MILLIAMPS.

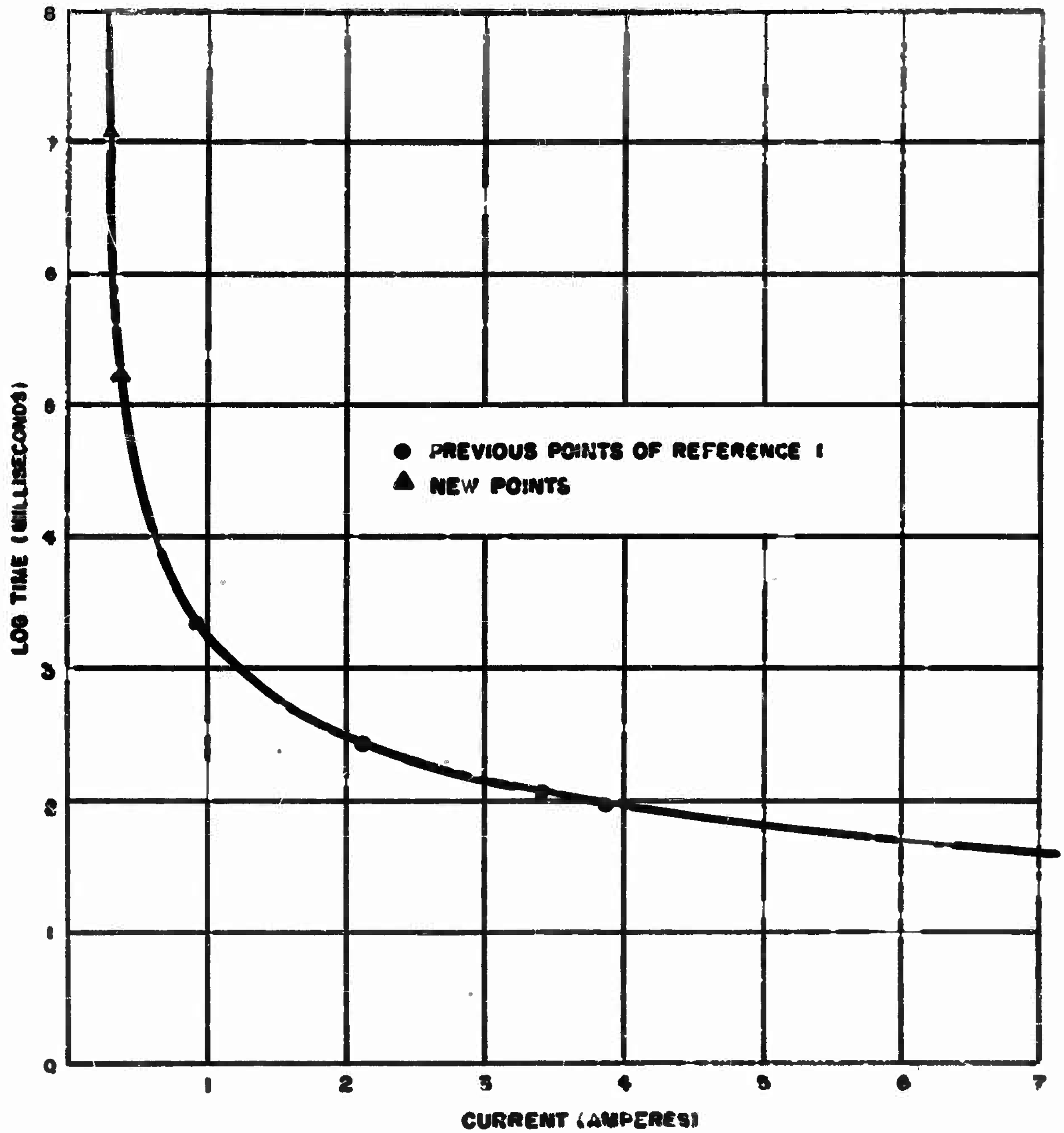


FIG. 5 RESPONSE OF SQUIB MK1 MOD 0 TO CONSTANT-CURRENT (RMS) 5-MEGACYCLES PULSE.

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The response of the Squib Mk 1 mod 0 to 5-megacycle constant current (RMS) has been extended to long input times where the current amplitude for firing reaches a minimum asymptotic value. For a current amplitude of 374 milliamperes a pulse width of 155 milliseconds was found necessary to obtain 50-percent fires. When the current was allowed to flow for approximately 10 seconds (essentially steady state) a lower firing level of

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2. Squibs - Sensitivity
3. Squibs - Firing
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(NOL technical report 61-24)
CHARACTERIZATION OF SQUIB MK 1 MOD 0: 5-MEGACYCLE RF SENSITIVITY FOR LONG DURATION PULSES (U), by C. Goode and I. Kabik. 24 April 1961. 4p. charts. Projects 506-925/56015/0704, 506-924/56035/01073 and NOL 443. UNCLASSIFIED

The response of the Squib Mk 1 mod 0 to 5-megacycle constant current (RMS) has been extended to long input times where the current amplitude for firing reaches a minimum asymptotic value. For a current amplitude of 374 milliamperes a pulse width of 155 milliseconds was found necessary to obtain 50-percent fires. When the current was allowed to flow for approximately 10 seconds (essentially steady state) a lower firing level of

Abstract card is unclassified. (over)

1. Squibs - Mark 1 mod 0
2. Squibs - Sensitivity
3. Squibs - Firing
I. Title
II. Goode, Charles W.
III. Kabik, Irving, jt. author
IV. Project
V. Project
VI. Project

308 milliamperes for 50—percent response was determined. These values are consistent with previous data obtained at 5 megacycles for shorter pulse times and also with DC constant current firing data.

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